

## PATENT SPECIFICATION

DRAWINGS ATTACHED

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International Classification:—F 16 j 1/00.

## COMPLETE SPECIFICATION

## Improvements relating to pistons

We, GIRLING LIMITED, a British Company of Kings Road, Tyseley, Birmingham 11, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an improved form of piston, particularly but not exclusively for use in hydraulically actuated vehicle brakes, and a method of manufacturing pistons.

A known form of disc brake comprises a generally cup-shaped piston working in a cylinder open at one end, the open end of the piston projecting out of the cylinder and bearing against a back plate carrying a friction pad. To actuate the brake, hydraulic fluid under pressure is supplied to the cylinder to act upon the end face of the piston and force it outwardly and thereby cause the friction pad to be applied to the brake disc.

The cylinder bore and piston seal is protected by means of a flexible annular boot connected on the one hand to the open end of the cylinder and on the other hand to the outer end of the piston. To minimise the length of the piston, the boot is received in annular recess formed at the outer end of the piston so that the portion of the boot engaging the piston can be accommodated inside the cylinder when the piston is fully retracted (brakes "off" condition).

The piston is formed as a cold forging, and the recess is formed by machining the piston, so as to reduce the outside diameter of the outer end portion thereof, so that the wall thickness of the cylindrical wall of the piston is reduced in this region. The minimum thickness of metal remaining in this region is dictated by the loads which must

be transmitted by the piston, and as a result the remainder of the cylindrical wall is unnecessarily thick, resulting in turn in wastage of metal and excessive weight in the finished piston.

The present invention provides a piston of the general form outlined above, but modified to remove or minimise the stated disadvantages.

Broadly stated, the invention resides in a cup-shaped, cold-formed piston having a radially-inwardly deformed cylindrical portion at its open end.

More specifically, the invention includes a cup-shaped piston formed as a sheet metal pressing having at its open end an annular portion of reduced diameter but substantially equal wall thickness compared with the remainder of the cylindrical portion of the piston.

Preferably, the length of the piston is not greater than its outside diameter, and the end wall of the piston is curved concave outwardly, so that deflections of the piston in use and consequent stresses are reduced.

The invention also includes a method of making a piston of the above defined construction, comprising the steps of cold-forming a blank to form a cup having an end wall and a substantially cylindrical side wall, and then deforming the open end portion of the side wall radially inwardly.

A flat shoulder may be machined at the junction of the reduced portion with the remainder of the piston, and preferably the pressing operation is arranged so as to provide an upstanding shoulder in this region, the projecting part of which shoulder is machined off.

One form of piston and method of manufacture in accordance with the invention and some modifications will now be de-

scribed, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic section showing part of a disc brake assembly incorporating the piston;

Figures 2 to 5 show successive stages in the formation of the piston;

Figure 6 shows a modified piston, and

Figures 7 to 12 illustrate some methods of re-shaping a cup shaped piston formed as a metal pressing.

In Figure 1, a cup-shaped piston 1 working in a brake cylinder 2 bears against a brake backplate 3 carrying a friction pad 4 which co-operates with a brake disc 6.

At its outer end, the piston is formed with a circumferential recess 7 which receives the inner peripheral portion of a flexible annular boot 8, the outer periphery of which is secured to the cylinder 2.

As so far described, the piston is of known form, but the known pistons are formed by cold forged blanks, with the recesses machined in, so that the wall thickness at the recess is substantially less than that of the rest of the cylindrical wall of the piston.

In accordance with the present invention, however, the recess is created by deforming radially inwardly the outer end portion of the piston.

One method of forming the piston from a circular sheet metal blank is illustrated in Figures 2 to 5.

The forming stages, in succession, are as follows:

First, the blank is drawn into the form of a plain cup having a flat end wall 11 and a cylindrical side wall 12 (Figure 2);

Secondly, the cup is pressed so as to upset the metal around the mouth of the cup to form a cylindrical ring 13 of reduced internal and external diameter, joined to the rest of the wall 12 by a smoothly blended shoulder 14. Preferably simultaneously, the end wall 11 is deformed into the upwardly convex curved form shown in Figure 3;

Thirdly, in a separate press tool, the shoulder 14 is upset to the undercut form shown in Figure 4, the metal outside the undercut forming an upwardly projecting shoulder 14A, and

Finally, the projecting shoulder 14A is machined off to leave a sharp cornered recess 7 having a flat axial shoulder as shown in Figure 5.

This method of forming the piston results in a final product of substantially constant wall thickness, so that the stress distribution is substantially uniform and without substantial wastage of metal. The curvature of the end wall 11 lends extra rigidity, which is preferably further enhanced by

maintaining the length of the piston equal to or less than its outside diameter, although the length may exceed the outside diameter in some cases, and could, for example be equal to twice the diameter.

The second stage operation described above may be carried out by means of a two-stage press tool comprising a central punch or mandrel which enters the cup prior to an outer ring being forced down over the upper end of the cup to force the upper end portion inwardly against the central punch. The third stage may be effected in similar manner, but with the outer ring having an axially projecting lip to bite into the shoulder to form the undercut.

In a slightly modified piston, shown in Figure 6, an annular groove 16 is machined at the junction of the reduced diameter portion 13 with the rest of the side wall, to receive, in use, a thickened rim of the sealing boot 8.

Another important and useful characteristic of the method described above, is the reduction of the external radius R between the end and side walls of the piston, readily noticeable from a visual comparison of Figures 2 and 3. This reduction in radius being effected by the application of an axial compressive load in the forming of the reduced diameter portion 13 and curving of the end wall 11. This reduction of the radius R in pistons formed as metal pressings is of particular value in vehicle disc brake assemblies, in which it can result in a saving of about  $\frac{1}{4}$  inch (3.18 mm) in the overall width of the brake, with a corresponding saving in weight, not only of the piston but of the brake cylinder body and other associated components. In mass produced brakes, such savings are of great economic value.

Some other possible methods of achieving this reduction in radius are illustrated in Figures 7 to 12 inclusive, characterized in each case by an operation including the step of applying an axial compressive load to the cup-shaped piston to vary the radius in question.

In Figure 7, the piston having a radius R is pressed on its open end into a die 17 to effect reduction of the radius. The radius and overall length are thus reduced as shown in Figure 8. In Figure 9, a central punch or mandrel 18 is employed to work on the corresponding internal radius.

In Figure 10, the piston is subjected to a compressive load which causes the base portion of the cup to swell out over an annular zone, and the operation is completed by machining off the excess material as indicated by the lines M.

In Figure 11, the axial pressure is applied to dome the end wall 11 so that effectively,

a bulge is created over an annular zone adjacent the radius, and excess material is then removed as indicated by the line M.

Figure 12 illustrates a method which comprises a combination of the methods of Figures 10 and 11.

#### WHAT WE CLAIM IS:

1. A cup-shaped, cold-formed piston having a radially inwardly deformed cylindrical portion at its open end.
2. A cup-shaped piston formed as a sheet metal pressing having at its open end an annular portion of reduced diameter but substantially equal wall thickness compared with the remainder of the cylindrical portion of the piston.
3. A piston in accordance with claim 1 or 2, wherein the diameter of the piston is at least as great as the length.
4. A piston in accordance with claim 1, 2 or 3, wherein the end wall of the piston is curved concave outwardly.
5. A piston in accordance with any preceding claim, wherein a flat shoulder facing towards the open end of the piston is machined at the junction of the said portion of the piston with the remainder of the piston.
6. A piston in accordance with any one of claims 1 to 4, wherein an annular groove is machined in the piston in the region of the junction between the said portion and the remainder of the piston.
7. A method of making a piston in accordance with any one of claims 1 to 5, comprising the steps of cold-forming a blank to form a cup having an end wall and a substantially cylindrical side wall, and

then deforming the open end portion of the side wall radially inwardly.

8. A method in accordance with claim 7, wherein the blank is of sheet metal and is formed to a cup shape by pressing.

9. A method in accordance with claim 7 or 8 as appended to claim 5, wherein the piston is formed with an upstanding shoulder in the region of the said junction, and the upstanding shoulder is subsequently machined off to leave the said flat shoulder.

10. A method in accordance with claim 8, wherein the cup formed by the pressing operation is subsequently subjected to an axial compressive load to reduce the external radius at the junction of the side wall with the end wall.

11. A method in accordance with claim 10, modified in that the said compressive load causes the wall of the piston in the region of the junction between the side and end walls to be increased locally in diameter or displaced axially relative to the end wall or both, and excess material is then machined off, thereby reducing the said external radius.

12. A cup-shaped, cold-formed piston, substantially as herein described with reference to Figure 5 of the accompanying drawings.

13. A cup-shaped, cold-formed piston, substantially as herein described with reference to Figure 6 of the accompanying drawings.

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COMPLETE SPECIFICATION  
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SHEET 1

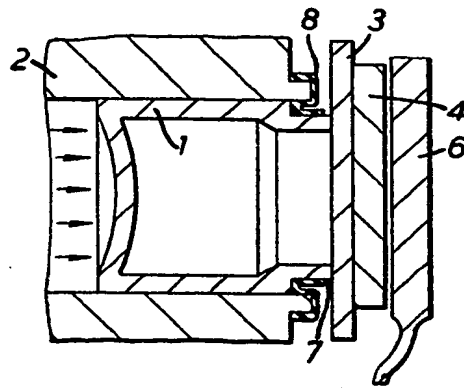


Fig. 1.

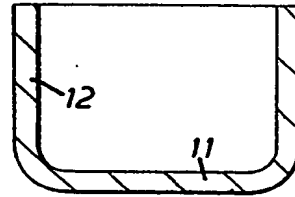


Fig. 2.

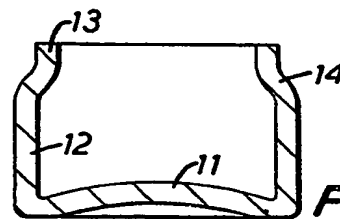


Fig. 3.

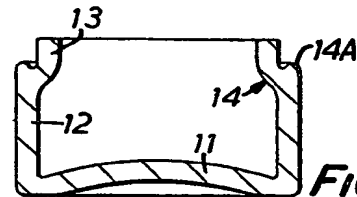


Fig. 4.

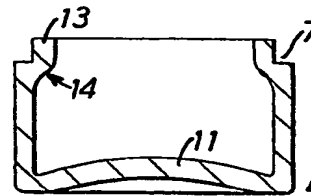


Fig. 5.

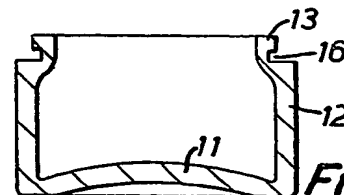


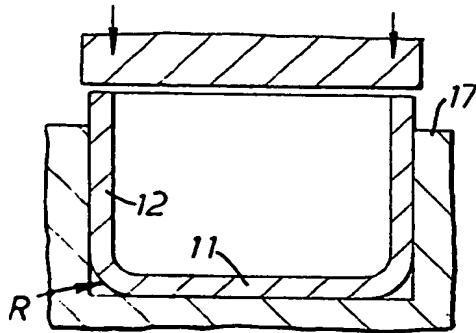
Fig. 6.

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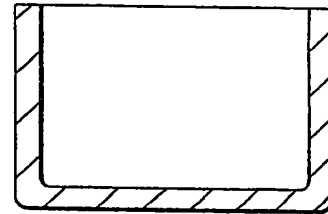
COMPLETE SPECIFICATION

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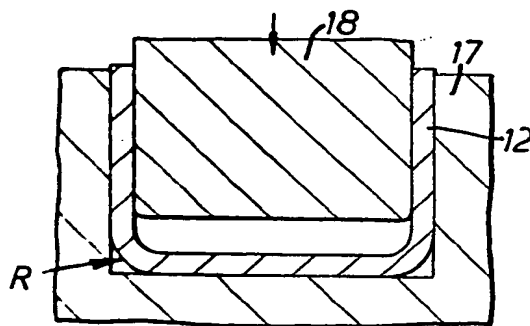
SHEET 2



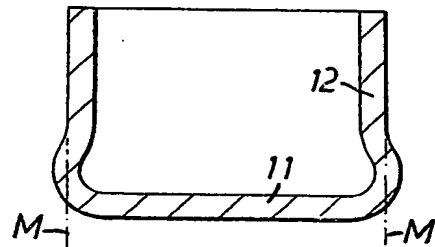
**FIG. 7.**



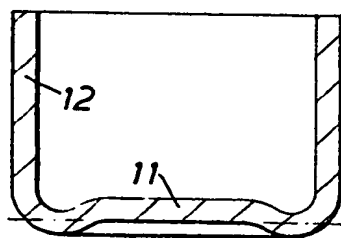
**FIG. 8.**



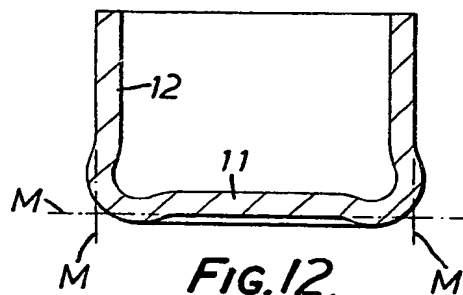
**FIG. 9.**



**FIG. 10.**



**FIG. 11.**



**FIG. 12.**